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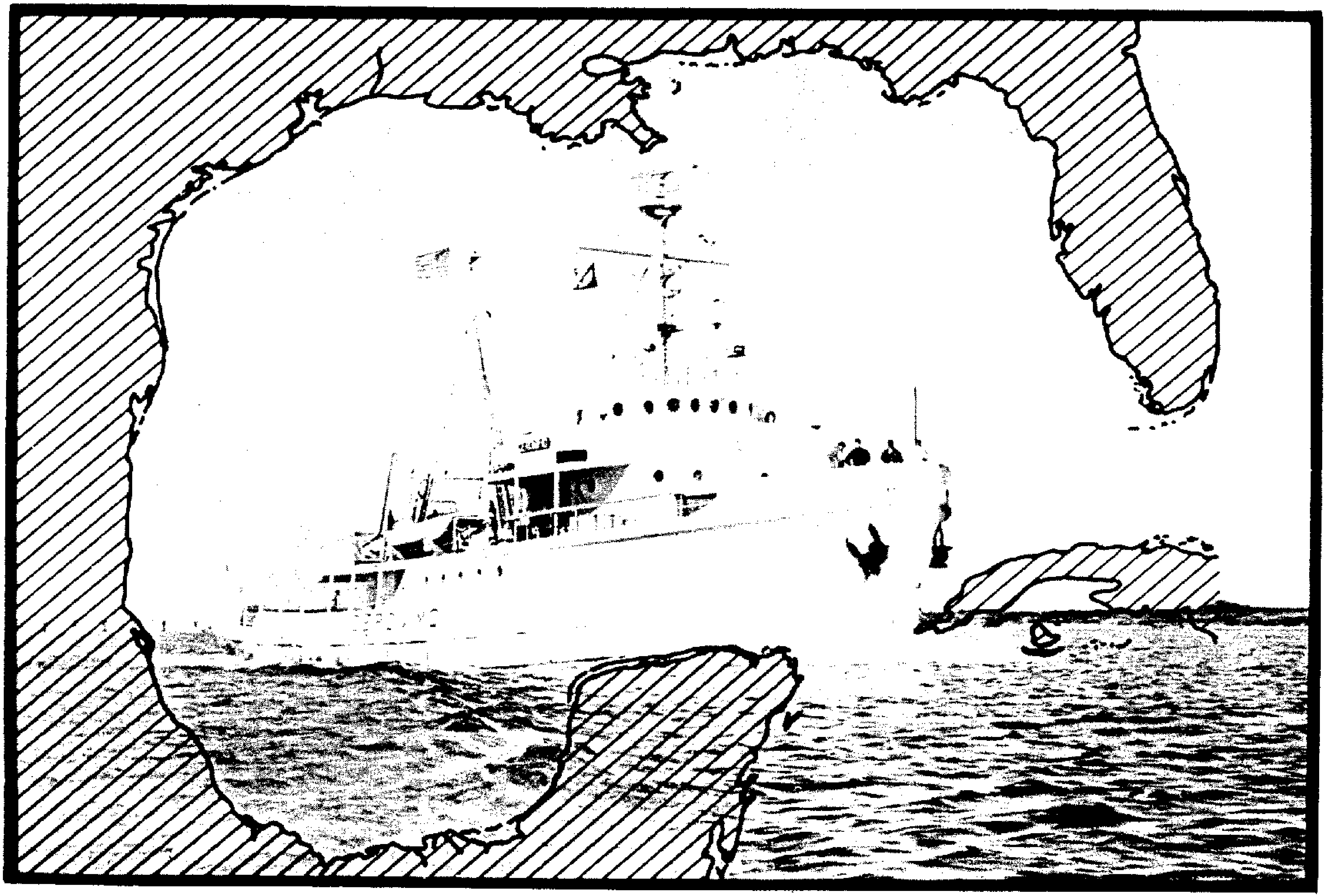
REPORT OF THE BUREAU OF COMMERCIAL FISHERIES BIOLOGICAL LABORATORY, GALVESTON, TEXAS, FISCAL YEAR 1968



UNITED STATES DEPARTMENT OF THE INTERIOR

U.S. FISH AND WILDLIFE SERVICE

BUREAU OF COMMERCIAL FISHERIES

Circular 325

Because of the threat of Hurricane Beulah, we harvested the shrimp prematurely on September 19, 1968, from the fertilized and untreated ponds. Shrimp in the fertilized pond attained an average total length of 103.7 mm. (4.1 inches) and a weight of 9.3 g. (0.3 ounce) over the 145-day study period. Thirty-one percent of the shrimp survived to produce an estimated projected yield of 314 kg. of tails per hectare (280 pounds per acre). Shrimp in the untreated pond attained a total length of 88.6 mm. (3.5 inches) and a weight of 5.3 g. (0.2 ounce); 23 percent survived to produce an estimated projected yield of 135 kg. per hectare (120 pounds per acre).

The low survival (31 and 23 percent) of shrimp in the ponds was attributed to oxygen depletion rather than cannibalism or disease. The levees surrounding the ponds partially obstruct the wind and thereby limit circulation and aeration. On several occasions when a bloom of phytoplankton was dense, the depletion of oxygen in the ponds caused distress and mortality among shrimp. In the future we will attempt to eliminate this cause of mortality by aerating the ponds' waters mechanically.

To gain better understanding of the ecology of the ponds as related to shrimp growth, we periodically examined water samples to determine the density of algal growth, the abundance and composition of zooplankton, and the physical and chemical conditions of the water. Also, samples of substrate were analyzed for bottom organisms. The succession of nutrients, phytoplankton, zooplankton, and populations of bottom fauna were in close agreement, but contrary to what was expected, shrimp grew best early in the study when populations of zooplankton and bottom organisms were lowest.

The abundance of organisms in our ponds tended to follow, in general, the rise and fall of the temperature during the year. Organisms were most plentiful in the summer and least abundant in the winter. The ratio between the number of bottom organisms collected in the summer and winter was 4:1; for plankters, it was 94:1.

In mid-October a single pond was stocked with about 2,900 laboratory-reared postlarvae (brown shrimp) averaging 12 mm. (0.5 inch) total length to determine their ability to overwinter. When we harvested the shrimp on May 31, we learned that 42 percent of the shrimp survived temperatures which decreased to a 3-month average low of 8.9° C. (48° F.) in January-March. Average daily growth was greatest in the spring when temperatures were increasing and least in the winter when temperatures were lowest (table 6). Burrowing was most pronounced in the winter.

Earthen levees were recently built across our two ponds to form four smaller ponds, each about 0.02 hectare (0.05 acre). The depression formed by removing soil to construct these levees created an additional pond. All ponds were drained, and we are now in the process of restocking them with brown shrimp about 75 to 100 mm. (3-4 inches) long. The purpose of this study is to find means of accelerating the growth which became slow at about this size in previous years.

Table 6.--Growth of brown shrimp stocked as postlarvae in a brackish-water pond, between October and June, 1967-68

Time period	Average water temperature		Average daily growth		Size attained during period	
Date	°C.	°F.	Mm.	Inches	Mm.	Inches
Oct. 19 to Dec. 31	21.1	70	0.43	0.017	43.7	1.72
Jan. 1 to Mar. 31	8.9	48	0.05	0.002	47.8	1.88
Apr. 1 to May 31	22.8	73	1.09	0.043	115.6	4.55

Ray S. Wheeler, Project Leader

Food and Experimental Environments

To grow shrimp rapidly to maturity in artificial environments, we must know the types and amounts of food eaten and preferred by shrimp. Juvenile penaeid shrimp fed live brine shrimp (Artemia) nauplii in the laboratory decreased in growth rate after reaching 50 mm. (2 inches) total length. In pond experiments, shrimp have all but ceased growth after reaching 127 mm. (5 inches) total length. Although environmental factors such as light, salinity, oxygen level, or population density may influence the growth of shrimp, the amount and qualify of food probably have more effect. Accordingly, we began experiments during the past year to evaluate the nutritional value of prepared foods.

In our initial study with juvenile pink shrimp from Florida, a food with a fish-flour base supplemented with vitamins supported better growth (as indicated by the frequency of molting) and survival than did a diet of Artemia nauplii (fig. 1). Only 2 of 23 shrimp fed Artemia were alive at the end of 90 days; both had opaque, white flesh and were generally inactive. In contrast, 22 of 23 fed the fish flour plus vitamins survived the same period; all survivors had clear, transparent flesh, were active, and were continuing to grow.

In a second experiment, postlarval brown shrimp from Galveston Bay were fed several prepared foods containing various amounts of fish meal and vegetable flours in the form of pellets and an agar-base gel. Postlarvae fed the experimental diets did not attain the size of those fed Artemia nauplii. Foods containing large amounts of vegetable proteins--soy flour or cottonseed meal--were not eaten by either juvenile or postlarval brown shrimp. Foods

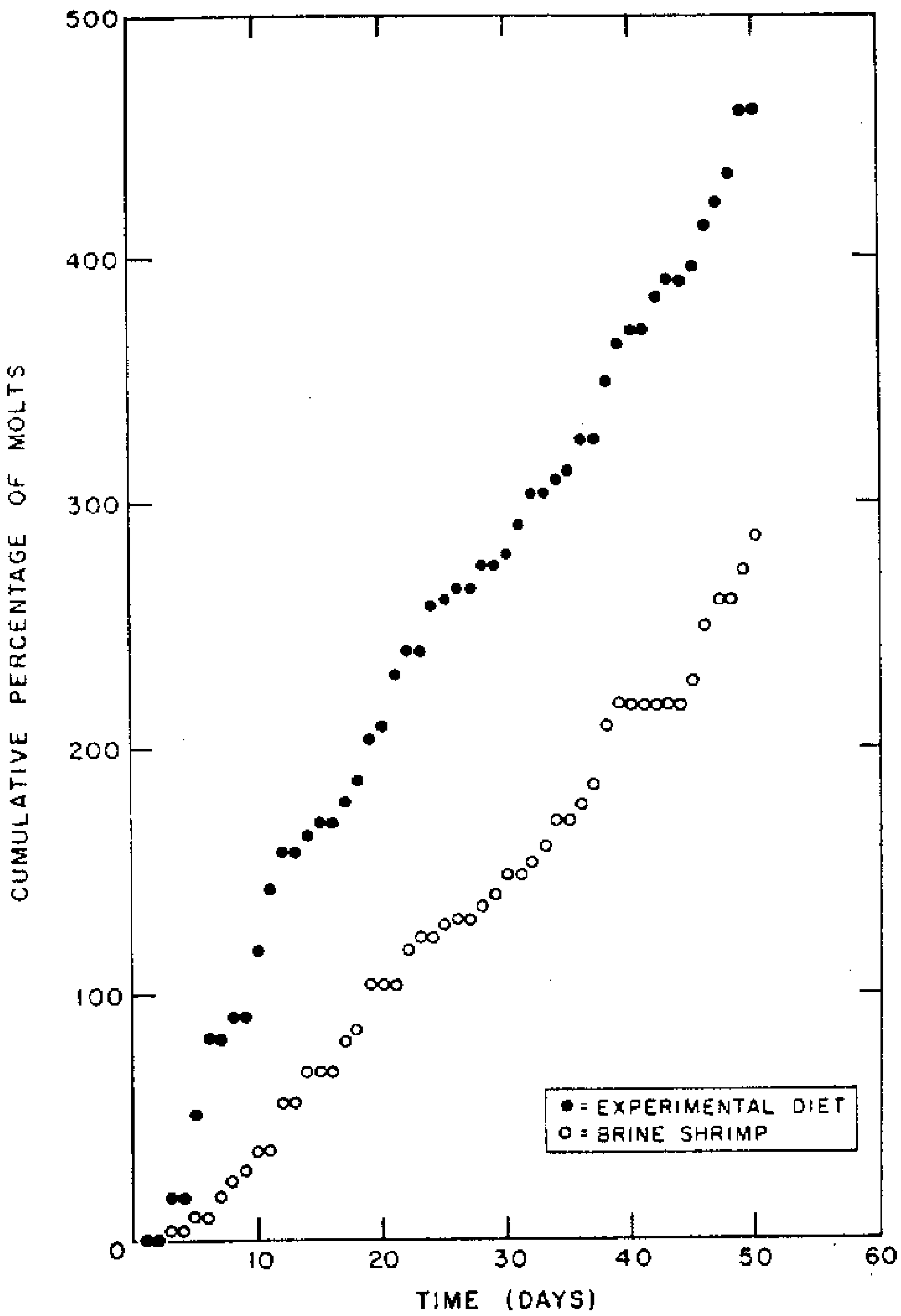


Figure 1.--Cumulative percentage of molts of pink shrimp fed enriched experimental diet and brine shrimp nauplii.

with a fish-flour base (with or without a vitamin supplement) were readily and continuously eaten by postlarval and juvenile shrimp. The postlarvae, however, were extremely cannibalistic and less than 50 percent survived for 1 month. The contrast in cannibalism between juveniles and postlarvae suggests that postlarvae may require a greater density of food, a different method of feeding, or a different combination of foods than juvenile shrimp.

Several natural foods also were fed to juvenile shrimp. These included shucked mussels and clams; several species of polychaete worms; amphipods; nauplial and adult brine shrimp; postlarval seabobs; and a natural mat composed chiefly of small tube-dwelling polychaetes, amphipods, a few mollusks, and small nematode worms, all bound in a rich organic matrix. Each food was eaten when presented alone, but the response to simultaneous presentation of combinations of foods varied. Polychaetes were usually a preferred food, but a shrimp tended to continue eating whichever type food it first contacted. For example, the shrimp that first ate Artemia continued to eat Artemia, and shrimp that first ate mussels continued to search for mussels.

The food preference of the shrimp depended somewhat on the size of the shrimp tested. Juvenile brown shrimp less than about 25 mm. (1 inch) total length did not react to the presence of the natural food mat and did not graze on the mat even if it remained in the aquarium for 2 or more days. When food was introduced, animals of 38 mm. (1.5 inches), however, became excited and fed actively.

The size and speed of the food organism are additional factors in the choice of food for shrimp that are being cultured. Brown shrimp 25 mm. (1 inch) total length were able to catch and eat slowmoving adult Artemia about 10 mm. (0.4 inch) long. These same animals however, were able to eat water boatmen 6 mm. (0.3 inch) long only when the insects swam into the mouth appendages. In contrast, brown shrimp 75 mm. (3 inches) long ate all the small foods as well as postlarval seabobs 18.9 mm. (0.8 inch) to 25 mm. (1 inch) total length.

Direct observation of the feeding behavior of juvenile and adult shrimp suggests two distinct processes in locating food. First there is a nondirectional swimming in response to the presence of dissolved chemicals in the waters. Secondly, the animals return to the substrate and search actively for the food. During this latter process, the chelated legs of the shrimp must touch the suspected food, which may be rejected at the mouth. The function and action of the food-gathering appendages are being studied through the use of slow-motion films.

Laboratory-hatched postlarval seabobs were exposed to selected combinations of temperature and salinity for a 24-hour tolerance and a 28-day growth experiment. Because previous studies suggested that these animals were less tolerant of environmental change than either the brown or white shrimp, we exposed them to a narrower range of salinities and increased the acclimation period. The postlarval seabobs were exposed to salinities of 10, 15, 25, 29, or 35 p.p.t. at temperatures of 15° C. (59° F.), 18° C. (64° F.), 25° C. (77° F.), or 32° C. (90° F.). No animals survived 28 days at any salinities at 15° C. (59° F.), and only 11 percent survived at the control salinity (29 p.p.t.) at 18° C. (64° F.). Between 40 and 50 percent survived salinities of 25 to 35 p.p.t. at 25° C. (77° F.), but less than 30 percent survived salinities of 10 and 15 p.p.t. at 25° C. (77° F.) and each salinity tested at 32° C. (90° F.). The high mortality and the slow growth that accompanied it suggest that this species is not suitable for pond culture, although the postlarvae might be a good food for other penaeid shrimp.

Studies of digestive enzymes indicate that penaeid shrimp possess the three major types--carbohydrases, lipases, and proteases. More detailed work is in progress.

During the year, we equipped the invertebrate culture facility being used by the National Aeronautics and Space Administration Lunar Receiving Laboratory. T. A. Tyler has several organisms in culture, and is assisting in the identification of various micro-organisms occurring in both sea water and shrimp tissue.

Zoula P. Zein-Eldin, Project Leader

Ecology of Pink Shrimp in Florida Bay

Ecological studies in Florida Bay and the Florida Keys (fig. 2) have produced a variety of information on young pink shrimp, Penaeus d. duorarum, not previously available. These shallow waters are the prime nursery grounds for pink shrimp of the Tortugas fishery.

Postlarvae of the pink shrimp enter the Florida Bay estuary from the Atlantic Ocean through channels in the Florida Keys and live on the bottom in suitable, shallow-water, grassy areas. These shrimp settle in greatest numbers near shorelines, and apparently prefer bottoms with growths of shoal grass, Diplanthera wrightii.

Quantitative samples of planktonic postlarval shrimp entering Florida Bay via Whale Harbor Channel were taken monthly for 30 months. Seasonal peaks of shrimp abundance were in the spring, summer, or fall. The numbers of incoming planktonic postlarvae are reflected by the numbers of benthic postlarvae caught at selected sampling stations in Florida Bay and the Keys (fig. 3). Planktonic and benthic postlarvae were most abundant from June to December in 1967.

The numbers of shrimp in samples from 18 selected stations in October 1967 give a general picture of shrimp distribution in Florida Bay and the Florida Keys (fig. 2). Northeastern Florida Bay has little water exchange with the Atlantic Ocean and contains a relatively small number of shrimp. The central Bay, with water circulation somewhat restricted by shallow mud banks, has moderate numbers of postlarval and juvenile shrimp, whereas the western Bay, with a large volume of incoming Atlantic water, has an abundance of young pink shrimp. The Lower Keys have moderate numbers of shrimp; the limiting factor here may be the shallow substrates that restrict the growth of seagrasses.

Thomas J. Costello, Project Leader
Donald M. Allen

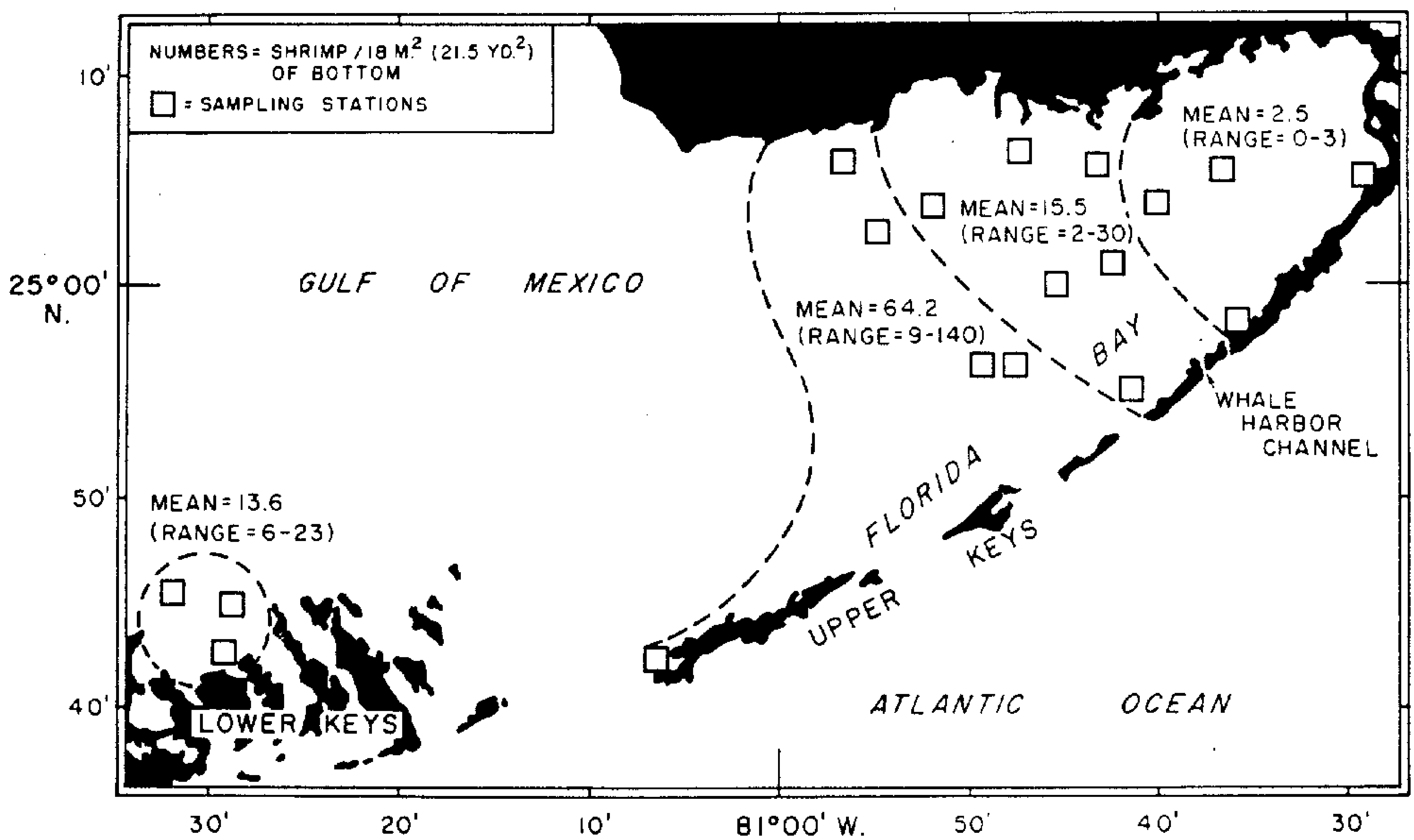


Figure 2.--Relative density of postlarval and juvenile pink shrimp in Florida Bay and the Florida Keys, October 1967.